Real or surreal: A pilot study on creative idea generation in MR vs. VR

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Abstract

The present pilot study examined collaborative creativity in virtual and mixed reality (VR vs. MR). Comparing equivalent VR and MR environments, we explored whether different environments can potentially influence users' creative production when asked to generate new ideas on water and energy sparing. We adopted the Linkography approach to evaluate participants creative performance by assessing not only the final brainstorming output but also the step-by-step processes of forming ideas [2]. We looked at both participants' individual ideas (i.e., *node*) and their relationships with other ideas (i.e., *link*). Our results demonstrated participants generated ideas with greater fluency and originality when they were in the VR condition. Implication and avenues for future work are discussed accordingly.

Index Terms: Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality

1 Introduction

What is the effect of immersive technology on one's creativity? Several studies have directly or indirectly addressed the research interest, but much remains to be explored. The unique nature of immersive technology offers a number of opportunities to manipulate experiences in VR or MR, including altering the way an avatar appears or is controlled, leveraging the ability to record or replay one's creative processes, or manipulating different forms of presentations for various sensory information. The present study uses pilot data from a single-factor experiment with two conditions to compare whether two different environments, presented by virtual reality (VR) and mixed reality (MR), differently impact users' idea generation processes and on their creative outcomes.

2 Related Work

Former literature studying immersive technology as an idea generation environment focused on eliciting bizarre experiences in a virtual space and investigating its effect on participants' creativity. For example, researchers have investigated whether novel experiences, such as wandering in the sky or outer space, would affect one's creativity [6]. Other research visualized abstract, symbolic metaphors, for example, presenting a huge light bulb in a virtual world [5] or placing participants inside versus outside a box [3]. Another line of research allowed participants to receive sensory feedback from the environment through multiple sources [4].

In our study, we used two very simple environments to determine whether the novel experience of VR *in itself* changes users' creative output. The present study exploits a comparison of MR and VR to test whether the simple experience of the environment and avatars being rendered in a non-photorealistic manner is sufficient to affect participants' idea generation. In our study, both the VR and the MR conditions included visual representations of abstract concepts (i.e., both conditions had unreal digital objects showing in the environment), but the surrounding environment was either realistic (a video feed in the MR condition) or obviously mediated (digital models and avatars, in the VR condition). In this preliminary study, we examined how the two environments might differently affect users. To the best of our knowledge, there is no existing literature directly comparing different immersive technology formats on creativity. To assess participants' individual and paired creativity scores, we adopted the Linkography approach to evaluate the effect of environment [2]. Besides looking at the outcomes of idea generation (such as the rarity and total count of ideas), the Linkography approach also takes into account the *process* of creative production.

3 Research Design

The present research piloted a single-factor study with two conditions: MR vs. VR environment. Eight study subjects were recruited from the participant pool of a large university and were compensated by course credits. This study was approved by the IRB. We randomly assigned participant pairs and instructed each pair to work together on brainstorming ideas for water and energy conservation. Each pair was then randomly assigned to the MR or VR condition. In both conditions, participants would see the same menu with colorful blocks shown in Figure 1. In the MR condition, participants saw the actual environment they were located in (i.e., a standard lab room) and their partners' actual appearance. In the VR condition, participants entered a virtual model of the lab and their partners appeared in genetic avatar bodies. Participants' conversations were audio recorded, transcribe and then coded as described below.

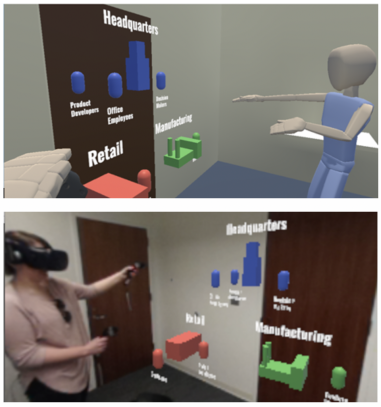

Figure 1: Experimental stimulus of the two conditions. Top: VR environment; bottom: MR environment.

4 Measurement

The present study adopts the Linkography approach to analyze the effect of environment on participants' creative processes and outcomes [2]. Using transcriptions of participants' conversation, we coded each idea into a *node* and the relationship between ideas into *links*. For each node, we examined its *load of information* (on a scale of 0 to 3) and *divergence* (on a scale of 0 to 3); for each link,

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Table 1: Summary statistics and main effect of environment (MR vs. VR) on constructs of creativity. Tests of mean difference were assessed by independent t-tests and one-way ANOVA.

Factor	Mean (S.D.)	Independent t-test	One-way ANOVA	Conclusion
Load of information	MR: M= 2.00 ($S.D.$= 1.41) VR: M= 5.67 ($S.D.$= 2.58)	Equal variance: $t = -1.85, p = .11$ Unequal variance: $t = -2.52, p = .07$	$F = 3.43, p = .11$	No significance
Divergence	MR: M= 1.50 ($S.D.$= .71) VR: M= 3.67 ($S.D.$= 1.37)	Equal variance: $t = -2.07, p = .08$ Unequal variance: $t = -2.89, p = .05$	$F = 4.30, p = .08$	VR > MR (Marginal significance)
Count of node	MR: M= 2.50 ($S.D.$= .71) VR: M= 5.50 ($S.D.$= 1.23)	Equal variance: $t = -3.18, p = .02$ Unequal variance: $t = -4.24, p = .02$	$F = 10.13, p = .02$	VR > MR
Count of link	MR: M= 2.50 ($S.D.$= .71) VR: M= 5.50 ($S.D.$= 1.23)	Equal variance: $t = -3.18, p = .02$ Unequal variance: $t = -4.24, p = .02$	$F = 10.13, p = .02$	VR > MR
Logic with self	MR: M= .00 ($S.D.$= .00) VR: M= .67 ($S.D.$= .82)	Equal variance: $t = -1.10, p = .32$ Unequal variance: $t = -2.00, p = .10$	$F = 1.20, p = .32$	No significance
Logic with partner	MR: M= 1.00 ($S.D.$= .71) VR: M= 1.33 ($S.D.$= 1.03)	Equal variance: $t = -.43, p = .68$ Unequal variance: $t = -.79, p = .47$	$F = .19, p = .68$	No significance
Rarity of node	MR: M= 2.29 ($S.D.$= .98) VR: M= 4.73 ($S.D.$= .95)	Equal variance: $t = -3.13, p = .02$ Unequal variance: $t = -3.06, p = .01$	$F = 9.82, p = .02$	VR > MR
Rarity of link	MR: M= 2.48 ($S.D.$= .71) VR: M= 5.31 ($S.D.$= 1.11)	Equal variance: $t = -3.27, p = .01$ Unequal variance: $t = -4.17, p = .02$	$F = 10.72, p = .01$	VR > MR
Creativity Scores	MR: M= -8.11 ($S.D.$= 2.89) VR: M= 2.70 ($S.D.$= 4.83)	Equal variance: $t = -2.90, p = .02$ Unequal variance: $t = -3.81, p = .02$	$F = 8.42, p = .02$	VR > MR

we assessed whether it formed a logical connection with the participants' previous node (*logic with self*, binary coding) and with their partners' previous node (*logic with partner*, binary coding). We also calculated the total count of nodes and links (i.e., *count of node* and *count of link*) as well as their within-group probability density (i.e., *rarity of node* and *rarity of link*).

5 Results

Despite the small sample of participants, we got multiple links and nodes from each study subjects (81 links and 38 nodes in total), giving us sufficient number to run further analyses. Using one-way ANOVAs and independent sample t-tests, we found significant main effects of the experimental conditions on various aspects of creativity, including the total count of nodes, the variety of link types, and the rarity scores for both links and nodes. Specifically, participants showed greater performance in these areas when they were in VR, as shown in Table 1. We summed these constructs to calculate a total score of creativity for each participant, using their standardized values for calculation. In results, the total scores of creativity were significantly higher for participants in the VR condition than for participants in the MR condition. Summary statistics are also presented in Table 1.

According to participants' open-ended responses, they described the study as "creative and exciting," but they also suggested "it's a bit odd to use MR/VR in this way". Others pointed out it was difficult to feel like one was working with another person when s/he could not read the partner's facial movements and natural reactions.

6 Discussion and Future Work

The present study examined the effect of VR and MR environments on idea generation. Adopting the Linkography approach, we found participants who experienced the VR environment generated higher scores on various constructs of creativity. We propose that the level of realism of the environment itself may play a role in creative ideation. However, there are other potential explanations to be investigated; for example, whether the perceived anonymity of a virtual space may enhance creativity.

There is also the need for future research to explore how experiences in VR may affect creativity. We propose at least two plausible directions to investigate mechanisms. The first, based on the Arousal Theory of Creativity [7], VR may offer sufficient arousal to boost initial idea generation. Whether a highly stimulating environment is ideal for formation of concrete ideas, which may better develop in low arousal conditions, needs further investigation. Secondly, the surreal qualities of virtual space may nurture the *flexibility* aspect of creativity [1]. Comparing the effect of VR on abstract versus concrete thinking may be another pathway for future research.

VR experiences may aid creativity but not help form logical connections. leaving it unclear what effects VR might have on more complex creative tasks. Also, VR participants may generate rare, original ideas, but whether they are practical remains to be examined. However, we hope the present pilot study opens the door to future studies to tackle the puzzles of creativity in VR.

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